COMPOSITIONAL SIMILARITY WITHIN THE OAKBRUSH TYPE IN CENTRAL AND NORTHERN UTAH

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Abstract.— Indices of similarity were used to evaluate the similarity of oakbrush stands throughout the Uinta National Forest and to compare oak communities in central and northern Utah. Results show that Gambel oak stands in central Utah differ significantly among themselves in respect to quantitative aspects of the vegetation. Those differences can be correlated with elevation, slope exposure, and fire history. Nevertheless, there is currently inadequate justification for recognizing more than one habitat type for the species in the study area. There is a need to develop a model capable of predicting growth rate of oak on specific sites.

The Gambel oak (*Quercus gambelii* Nutt.) community is an important constituent of big game winter ranges in Utah. Land managers responsible for this vegetation type desire to manage it so as to enhance wildlife habitat, provide maximum forage for big game, and maintain stable soil conditions on watersheds (pers. comm., Juan Spillett, wildlife biologist, Uinta National Forest). To develop a management scheme to meet those objectives, it would be helpful to know how similar oakbrush stands are within the area of concern. Accordingly, oak stands throughout the Uinta National Forest and surrounding areas have been examined for vegetational similarity using both quantitative and qualitative data.

Literature Review

For the most part, current oakbrush literature treats the oakbrush type as if it were uniform at all elevations, exposures, etc. A few studies indicate that there are regional and ecological differences within the Gambel oak type (Dixon 1935, Brown 1958, Cronquist et al. 1972). Those authors suggest that oakbrush is successional to ponderosa pine in southern Utah and Colorado. Allman (1953), Christensen (1958), Nixon et al. (1958), Nixon (1961, 1967), and Eastmond (1968) suggested that the oak zone is successional to maple in central Utah. Christensen (1964) reported that on north-facing slopes in Provo Canyon, Utah, oakbrush was successional to white fir and Douglas-fir. In Colorado, Steinhoff (1978) recognized seven different oakbrush associations with five successional stages in each. Although those associations tended to be quite similar, they were made distinct from each other by the presence or absence of a major plant indicator species for each of the groups.

Methods

Quantitative vegetational data were collected in 23 oakbrush stands located throughout the Uinta National Forest and in surrounding areas at different elevations and exposures. Of the 23 stands, 14 had been burned within the last 30 years, with the majority of those having burned within eight years of the sampling date. Nine of the burned stands were paired with adjacent, nonburned stands of approximately the same elevation, exposure, and slope.

Qualitative (species presence) data were also taken in an additional four oakbrush stands situated above 2040 m (6700 ft) and with north to east exposures. Quantitative data were collected from 0.04 ha (0.1 acre) stands using 25 quadrats of 0.25 m² area. Quadrats were uniformly placed across the surface of each stand. Species present in each quadrat were recorded and the foliage cover of each was estimated using the following cover classes: 0, no cover; T, $<1.0\%$; 1, 1–5%; 2, 5–10%; 3, 10–25%; 4, 25–50%; 5, 50–75%; 6, 75–95%; and 7, $>95\%$ cover.

Using quantitative data and all possible combinations of the 23 Central Utah stands taken two at a time, a stand matrix was con-

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structed based on Ruzicka's (1958) index of quantitative similarity. A cluster dendograph was drawn to illustrate the results of the Ruzicka interstand similarity matrix. The dendograph was constructed using the unweighted clustering method of Sneath and Sokal (1973). The average internal similarity among stands within each of the groups detected by cluster analysis was computed and each group was tested for significance of difference from other groups using the values for the Ruzicka index and analysis of variance.

In order to determine whether species composition (qualitative data only) differed significantly between unburned and burned stands or between higher elevations ($>$1830 m or 6000 ft) and lower elevation ($<$1830 m or 6000 ft) stands, all possible combinations of stands of concern taken two at a time were tested for qualitative similarity using the Jaccard (1912) coefficient of community. To maximize possible vegetational difference between stands, six stands above 2040 m (6700 ft) with north to east exposures were compared with six stands that occurred below 1740 m (5700 ft) and on south and west exposures. The method described by Beers et al. (1966) was used for converting aspect values (degrees) to a form that permits one to statistically test for aspect differences between groups of stands.

To compare the composition of central Utah oak stands with that for northern Utah oak stands, Ream's (1963) prevalent species list was compared with prevalent species lists for our burned and unburned stands taken separately and combined (Table 1). Both qualitative (Jaccard 1912) and quantitative (Ruzicka 1958) similarity indices were used to measure the degree of similarity between prevalent species lists from the central and northern Utah oakbrush zones. We have also evaluated the similarity of the foregoing prevalent species lists to the prevalent species list for northern Utah bigtooth maple stands sampled by Ream (1963).

Prevalent species were determined for all central Utah oak stands combined and for burned and unburned stands separately. Those species were selected using the method of Curtis (1959) as modified by Warner and Harper (1972). Curtis (1959) considered the number of prevalent species for a community to be equal to the average number of species per stand in that community type. Prevalent species were identified by ranking all species encountered in decreasing order of average quadrat frequency in all stands sampled. Prevalent species were then selected from the top of the list until a number equal to the average number of species per stand was reached.

RESULTS

Gambel oak stands (0.04 ha) in central Utah supported 25 plant species on the average (Table 1). Gambel oak itself was the most commonly encountered species in the study. Of the two next most abundant species, one was introduced (*Bromus tectorum*) and the other was native (*Galium aparine*). Both of the latter-named species were annuals. In total, the list includes six shrub species, six perennial grasses or grasslike species, four annuals, and nine perennial forbs. The most abundant associated shrub was snowberry (*Symphoricarpos oreophilus*); the most common grass was the introduced Kentucky bluegrass (*Poa pratensis*); and the most frequently encountered perennial forb was peavine (*Lathyrus pauciflorus*). There were 4.07 plant species per 0.25 m^2 quadrat.

When prevalent species were selected on the basis of fire history in oak stands (Table 1, columns 2 and 3), it is apparent that burning encourages annual plant species. The following annuals are over twice as frequent in burned as unburned stands: *Bromus tectorum*, *Collomia linearis*, *Epilobium paniculatum*, and *Lactuca scariola*. In burned stands, annuals contribute over 27 percent of the sum frequency of prevalent species, but in unburned stands, annuals account for only about 13 percent of the sum frequency of prevalents. Other plants that increased strongly with burning were *Artemisia ludoviciana*, *Chrysothamnus viscidiflorus*, and *Lupinus* sp.

In contrast, several species appeared to be severely reduced when oak stands burn. Both lichen (*Cladonia* sp.) and moss (*Polytrichum* sp.) frequently dropped to zero on burned areas. Big sagebrush (*Artemisia tridentata*) and bluebunch wheatgrass (*Agropyron spicatum*) were also seriously handicapped by fire.

TABLE 1. Average frequency of species found on the prevalent species list for different oak community types in Utah.

Species	Type[1] 1	2	3	4	5
Quercus gambelii	81.4	82.2	80.8	85.7	52.9
Galium aparine	34.6	36.8	33.1	23.1	49.0
Bromus tectorum	27.8	9.8	39.4	38.6	10.0
Poa pratensis	16.0	16.9	15.4	–	–
Symphoricarpos oreophilus	15.4	22.2	10.9	23.5	8.5
Lathyrus pauciflorus	12.2	10.2	13.4	6.5	13.2
Solidago sparsiflora	11.5	14.2	9.7	–	–
Achillea millefolium	11.2	17.3	7.2	10.5	11.3
Vicia americana	11.1	10.7	11.4	12.1	–
Viguiera multiflora	10.7	° 2.3	16.0	8.8	4.3
Carex hoodii	9.2	8.4	9.7	–	7.1
Amelanchier alnifolia	9.2	16.9	° 4.2	21.0	9.1
Agropyron spicatum	8.7	13.9	° 5.4	11.2	2.8
Prunus virginiana	8.4	12.4	5.7	15.5	33.3
Stellaria jamesiana	7.8	15.1	° 3.1	11.9	12.2
Epilobium paniculatum	7.3	° 3.1	10.0	–	–
Chrysothamnus viscidiflorus	7.2	4.4	8.9	–	–
Agropyron cristatum	7.1	–	11.7	–	–
Hydrophyllum capitatum	6.8	8.9	° 5.4	–	6.3
Rosa woodsii	6.4	7.1	6.0	9.4	3.7
Allium acuminatum	6.4	4.9	7.4	10.9	21.1
Lactuca scariola	6.4	° 1.0	9.8	–	8.5
Aster chilensis	6.1	4.0	7.4	–	–
Agropyron intermedium	5.6	° 0.4	8.9	–	–
Phlox longifolia	5.4	4.4	6.0	5.9	–
Collomia linearis	° 5.3	° 3.6	6.4	10.6	9.8
Elymus glaucus	° 5.2	8.9	° 2.9	–	8.8
Artemisia tridentata	° 5.0	9.6	° 2.1	26.9	12.3
Lupinus sp.	° 4.8	° 2.8	6.1	3.7	4.7
Cladonia sp.	° 4.7	9.8	° 1.4	–	–
Artemisia ludoviciana	° 4.7	° 1.0	7.0	7.2	0.8
Mahonia repens	° 4.6	7.7	° 2.6	10.0	12.8
Balsamorhiza sagittata	° 4.5	° 3.1	° 5.4	11.1	–
Bromus inermis	° 4.4	–	7.1	–	–
Taraxacum officinale	° 4.0	° 1.4	° 5.6	–	1.3
Polytrichum sp.	° 3.7	7.1	° 1.4	–	–
Melica bulbosa	° 3.1	° 1.3	° 4.3	–	3.2
Cirsium undulatum	° 3.1	° 0.9	° 4.6	2.6	–
Collomia grandiflora	° 2.1	° 0.4	° 3.1	6.3	7.5
Tragopogon dubius	° 1.9	° 0.9	° 2.5	1.7	–
Bromus japonicus	° 1.7	° 1.8	° 1.7	–	5.4
Agropyron subsecundum	° 1.7	° 1.3	° 2.0	–	6.7
Acer grandidentatum	° 1.6	° 2.7	° 0.9	7.5	74.3
Crepis occidentalis	° 1.2	° 1.3	–	3.1	3.1
Cynoglossum officinale	° 1.1	° 2.3	° 0.4	–	3.0
Purshia tridentata	° 0.9	° 2.2	° 0.1	4.4	–
Pachistima myrsinites	° 0.7	–	° 1.1	13.0	–
Polygonum douglasii	° 0.7	–	° 1.1	9.4	9.6
Wyethia amplexicaulis	° 0.5	° 1.3	–	7.5	5.2
Senecio integerrimus	° 0.4	° 0.4	° 0.3	3.0	3.4
Xanthocephalum sarothrae	° 0.2	–	° 0.3	5.6	–
Osmorhiza obtusa	–	–	–	–	10.3
Physocarpus malvaceus	–	–	–	–	9.3
Percent Σ Freq. contributed by prevalent species	83.5	91.9	85.2	–	–
Average no. of species/quadrat	4.07	3.99	4.17	4.28	4.45

[1]Type 1—23 oak stands in central Utah, including burned and unburned stands
Type 2—9 unburned stands in central Utah.
Type 3—14 burned stands in central Utah.
Type 4—Oak stands of northern Utah (after Ream 1963).
Type 5—Maple stands of northern Utah (after Ream 1963).
°Indicates nonprevalent species for that type.
Data for nonprevalent species unavailable on Ream's (1963) study plots (Types 4 and 5).

The latter two species probably reinvade burned areas quite readily, however. To compensate for losses of fire sensitive species, managers often reseeded perennial grasses into the ashes of burned oak stands. In this study, two grasses (*Agropyron cristatum* and *Bromus inermis*) undoubtedly owe their existence in oak stands to postfire seeding programs.

Our results suggest that few species are lost completely when an oak stand burns in our area. McKell (1950) concluded that northern Utah oak stands recovered quickly after fire: within nine years, grass species had returned to essentially prefire composition and cover. Shrub layer components were scarcely distinguishable from those of unburned stands after 18 years (McKell 1950).

Nevertheless, there is a marked change in Gambel oak stands in the first four years after a wildfire. In an attempt to quantitatively evaluate the compositional changes due to fire and other environmental influences on oak stands, we have clustered the 23 central Utah stands using the Ruzicka (1958) index of quantitative similarity and the unweighted mean clustering procedure of Sneath and Sokal (1973). The results (Fig. 1) show four distinct groups of stands that differ among themselves in respect to fire history, elevation, and exposure. The most recently burned stands occurred at lower elevations (Table 2): that pattern is probably a reflection of the frequency with which the average oak stand

Table 2. Comparisons among the four groups of oak stands shown on Figure 1. Groups are compared in respect to fire history, elevation, and exposure. Exposure is transformed using the procedure of Beers et al. (1966).

	Group			
Characteristics	1	2	3	4
No. stands in group	6	7	7	3
Percent of stands that were recently burned	100	29	57	67
Average number of years since last burn[1]	3.5	9.0	9.3	19.0
Average elevation (m)	1,742	1,829	1,837	2,195
Average exposure[2]	0.97	1.36	0.65	0.32

[1]Only burned stands considered.

[2]Small values represent southerly exposures; larger values (>1.0) represent northerly exposures.

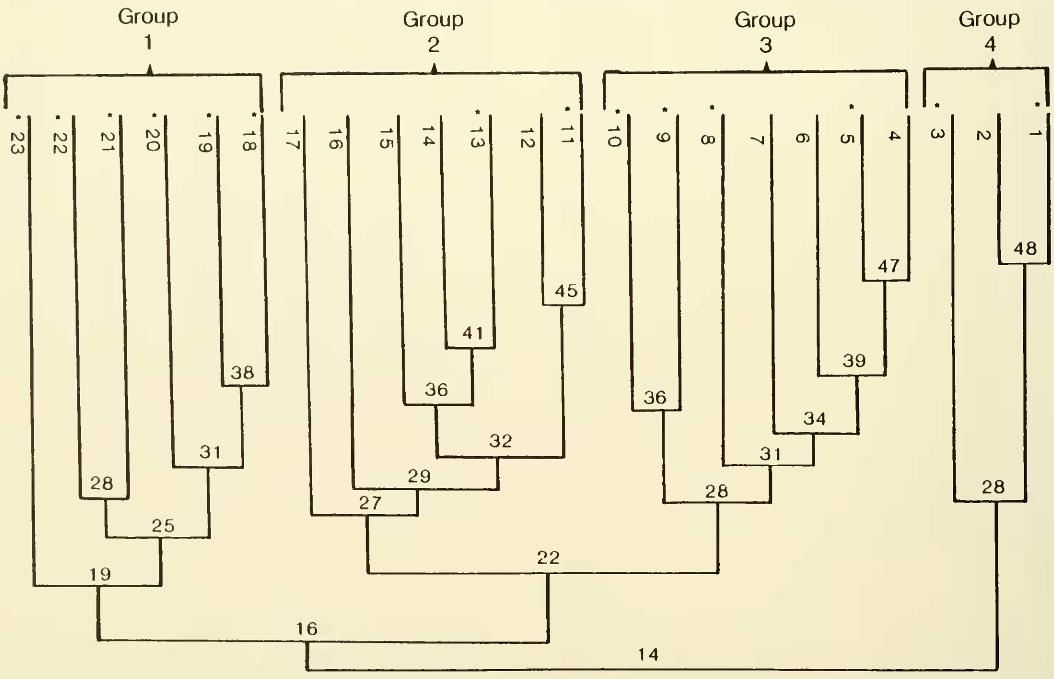

Fig. 1. Similarity dendograph based on percent similarity values among all possible two-by-two combinations of 23 oakbrush stands from central Utah. The similarity values are based on the Ruzicka (1958) index. Numbers at the branch ends are stand identification numbers. Other numbers at cluster points in the figure report the average similarity value among stands grouped at that level. Recently burned stands are designated by an asterisk by their number. Table 2 should be consulted in connection with this figure.

burns at low and high elevations. Fire history appears to be no more important than elevation and exposure in determining which stands cluster closely and are hence compositionally similar. Low elevations apparently favor some of the same species that increase with burning.

Considering only prevalent species for burned and unburned stands in our central Utah sample (Table 1), Jaccard's index shows those two groups to be over 48 percent similar. However, when both prevalent and nonprevalent species in Table 1 are considered, burned and unburned areas are 86 percent similar. Ruzicka's index of quantitative similarity (using frequency data) show the two lists to be 54 percent similar. These results agree with those of McKell (1950) and Hallisey et al. (1976), who show that, though burning affects the frequency of the species in oakbrush stands, it has few lasting effects on the species composition of those stands.

It is important to note that six high elevation stands on north-facing slopes were more similar to six low elevation stands on south-facing slopes by the Jaccard index (48 percent average similarity) than stands in either group were to each other (45 percent average internal similarity for the high elevation stands and 41 percent similarity among low elevation stands). An analysis of variance showed that between-group similarity differences were not statistically different from within-group differences. T-tests demonstrated that elevation and aspect did differ significantly between these two groups.

Perhaps the most significant aspect of Figure 1 is that within-group similarity is low even among stands of similar fire history. Group 1 is particularly impressive in that respect. Even when stands within groups are compared on the basis of species presence alone (Jaccard's index), within-group similarities are low. Average within-group similarity for groups 2 and 3 was only 57 and 45 percent using the Jaccard (1912) index. Between-group similarity using that index averaged 42 percent for groups 2 and 3 and 40 percent for all possible comparisons among the 23 stands. Thus, while Figure 1 demonstrates that recently burned stands often tend to be more like each other than like unburned or old-burn stands, they differ markedly among themselves. An analysis of variance test based on stand similarity within and between the groups of Figure 1 shows no statistical significance between groups. There is, thus, too much similarity among the stand groups derived from our sample to justify recognizing more than one Gambel oak habitat-type in central Utah.

How similar are northern Utah Gambel oak stands as sampled by Ream (1963) to those in our sample? We show the frequency of the prevalent species of Ream's (1963) oak samples in Table 1. Since bigtooth maple (*Acer grandidentatum*) is a successional species that displaces Gambel oak on many Utah sites, we also present Ream's (1963) list of prevalent species for the bigtooth maple community (Table 1). It will be noted that Ream recognized more prevalent species and more understory species per quadrat for the Gambel oak type than we show for central Utah (32 versus 25 prevalent species per stand and 4.3 versus 4.1 species per quadrat, respectively. Those differences are probably more a function of sampling methods than vegetational differences, since Ream's (1963) stands were at least three times and his quadrats four times larger than ours. His stands were apparently over 0.1 ha in size and his quadrats had an area of 1.0 m^2. In contrast, we used 0.04 ha stands and 0.25 m^2 quadrats.

We have assessed the similarity of Ream's (1963) Gambel oak and bigtooth maple prevalent species lists to the combined prevalent list for our 23 central Utah Gambel oak stands (Table 1). Similarity was determined using both quantitative (Ruzicka 1958) and qualitative indices (Jaccard 1912). The results (Table 3) demonstrate that similarity is always greater between central and northern

Table 3. Percent similarity of oak communities of central and northern Utah. Maple communities of northern Utah are also compared to the oak samples. Ruzicka's (1958) and Jaccard's (1912) indices are used for the comparisons.

	N. Utah Oak × C. Utah Oak	N. Utah Maple × C. Utah Oak	N. Utah Maple × N. Utah Oak
	Percent similarity		
Jaccard's	62.7	62.3	55.8
Ruzicka's	48.9	37.3	36.7

Utah prevalent species lists when the comparison is based on species presence alone (i.e., Jaccard's index). Furthermore, the central and northern Utah prevalent species lists are more similar than subgroups of Figure 1 are to each other. Thus, there appears to be no significant differences in composition of oakbrush stands in these two areas.

The central Utah oak community prevalent species list is less similar to the prevalent species list for northern Utah bigtooth maple communities than to the oakbrush prevalent species list for the northern area, but there is still a qualitative similarity of about 63 percent. Nevertheless, even that value is greater than the internal similarity among oak stands shown in Figure 1. It seems apparent that the bigtooth maple community is closely related to the oakbrush type in northern Utah. In all probability, most of the maple stands sampled by Ream (1963) were late seral stages of the oakbrush type.

Although there is inadequate data to support recognition of more than one Gambel oak type in central and northern Utah, there is obvious variation in oakbrush growth rates and terminal size in different ecological situations. There is a need to evaluate and describe site differences that contribute to the marked variations in growth rates of the species in this area. Such information would undoubtedly lead to a subdivision of the oakbrush type into ecological units that would have considerable utility for managers.

Conclusions

Considerable similarity exists between the prevalent species lists for oak stands in central Utah and prevalent species lists for that vegetational type in northern Utah. The results indicate that for general purposes, at least, one can consider the oakbrush zone of central and northern Utah as one vegetational type. Results further indicate that burning within the oakbrush zone of central Utah has an immediate effect on the ratio of shrub-to-herb forage production and on the ratio of annual-to-perennial herb production. Nonetheless, fire eliminates few, if any, species from oak communities, and burned stands quickly return to prefire species composition. There is a need to develop a model for predicting growth rates of Gambel oak on specific sites.

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